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National Eutrophication Survey, Corvallis, Oreg

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Report
on
O. C. Fisher (San Angelo) Reservoir
Tom Green County
Texas
EPA Region VI
Working Paper No. 676

With the cooperation of the
Texas Water Quality Board
and the
Texas National Guard
March, 1977

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

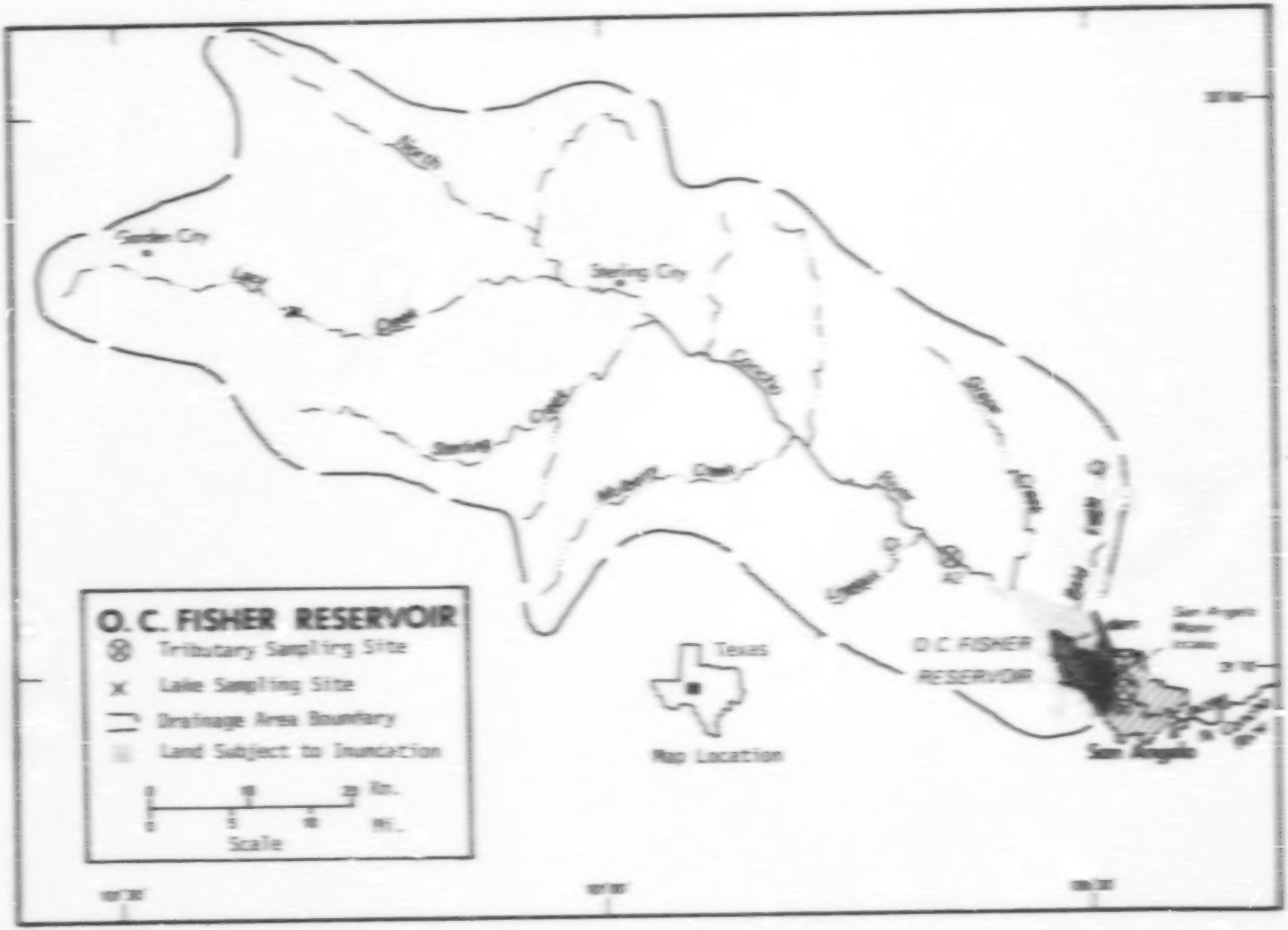
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somervillo	Burleson, Lee, Washington
T. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Raines, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, O
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


O. C. FISHER RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Land Subject to Inundation
Scale
Km.
Mi.
Texas
Map Location
O C FISHER
RESERVOIR
San Angelo

O. C. FISHER RESERVOIR

STORET NO. 4823

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that O. C. Fisher Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

O. C. Fisher Reservoir ranked thirty-second in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Thirty-three of the reservoirs had less median total phosphorus, 20 had less and one had the same median dissolved orthophosphorus, 21 had less median inorganic nitrogen, all of the other reservoirs had less chlorophyll a, and 35 had greater mean Secchi disc transparency.

Survey limnologists noted surface concentrations of algae in August.

B. Rate-Limiting Nutrient:

The algal assay results indicate the reservoir was nitrogen limited at the time the sample was taken (10/29/74). The reservoir data indicate nitrogen limitation in March as well but phosphorus limitation in May.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted O. C. Fisher Reservoir during the sampling year.

There are no lakeshore septic tanks because construction of shoreline dwellings if prohibited*.

Based on the reservoir morphometry at the conservation-pool level, the present phosphorus loading of 0.06 g/m^2/yr is about equal to that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 12). If Vollenweider's oligotrophic level is applicable to Texas water bodies, non-point phosphorus loadings to the reservoir in past years must have been much greater than measured during the sampling year since Survey data indicate O. C. Fisher Reservoir is eutrophic.

2. Non-point sources--All of the phosphorus input to the reservoir was contributed by non-point sources during the sampling year. The North Concho River contributed 63.1% of the total load, and the ungaged minor tributaries and immediate drainage added an estimated 12.5%.

The phosphorus export rate of the North Concho River was less than 1 kg/km^2/yr) (see page 11). This rate compares favorably with the rates of three tributaries of nearby Twin Buttes Reservoir*** (also less than 1 kg/km^2/yr).

* Koederitze, 1976.
** Anonymous, 1976.
*** Working Paper No. 666.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry (at conservation-pool level)[††]:

1. Surface area: 21.91 kilometers².

2. Mean depth: 6.5 meters.

3. Maximum depth: 18.5 meters.

4. Volume: 142,769 x 10^3 m^3.

5. Mean hydraulic retention time: 11.0 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
North Concho River	3,234.9	0.665
Minor tributaries & immediate drainage -	599.5	0.131
Totals	3,834.4	0.796

2. Outlet -

San Angelo water supply**	0.0	0.200
North Concho River	3,853.9***	0.210
Total	3,853.9***	0.410

C. Precipitation****:

1. Year of sampling: 63.8 centimeters.

2. Mean annual: 44.5 centimeters.

† Table of metric conversions--Appendix B.
†† Barrows, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Koederitze, 1976.
*** Includes area of reservoir.
**** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

O. C. Fisher Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at one station on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was collected for phytoplankton identification and enumeration; and a similar sample was collected for chlorophyll a analysis. During the last visit, a single 18.9-liter depth-integrated sample was taken for algal assays. The maximum depth sampled was 8.5 meters.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

[redacted]

[illegible]

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
03/04/74	1. Nitzschia sp.	9,005
	2. Ankistrodesmus sp.	4,407
	3. Chroomonas sp.	2,810
	4. Dactylococcopsis sp.	2,363
	5. Kirchneriella sp.	2,290
	Other genera	9,265
	Total	30,149
05/15/74	1. Nitzschia sp.	3,289
	2. Cyclotella sp.	2,380
	3. Raphidiopsis sp.	1,172
	4. Scenedesmus sp.	902
	5. Stephanodiscus sp.	901
	Other genera	7,119
	Total	15,771
08/05/74	1. Oscillatoria sp.	25,208
	2. Raphidiopsis sp.	10,905
	3. Dactylococcopsis sp.	8,355
	4. Pennate diatoms	6,381
	5. Merismopedia sp.	3,044
	Other genera	19,432
	Total	72,225
10/29/74	1. Chlamydomonas sp.	3,512
	2. Cyclotella sp.	1,115
	3. Cryptomonas sp.	725
	4. Chroomonas sp.	602
	5. Nitzschia sp.	602
	Other genera	2,005
	Total	8,361

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/04/74	1	13.1
05/15/74	1	24.7
08/05/74	1	42.6
10/29/74	1	18.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.035	0.109	5.2
0.050 P	0.085	0.109	4.9
0.050 P + 1.0 N	0.085	1.109	23.8
1.0 N	0.035	1.109	15.4

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of O. C. Fisher Reservoir was high at the time the sample was collected (10/29/74). The increased yield with the addition of nitrogen and the lack of response to phosphorus added alone indicate the reservoir was nitrogen limited at that time.

The reservoir data indicate nitrogen limitation in March also (the mean inorganic nitrogen/orthophosphorus ratio was 8/1) but phosphorus limitation in May (the mean N/P ratio was 19/1).

IV. NUTRIENT LOADINGS
(See Appendix I for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from the tributary site indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for the sampled tributary were calculated using mean annual concentrations and mean annual flows. Nutrient loads for the outlet (A-1) and the San Angelo water supply withdrawal were estimated using the mean reservoir concentrations at station 1 and the mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Concho River at station A-2 and the mean annual ZZ flow.

No known wastewater treatment plants impacted O. C. Fisher Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
North Concho River	880	63.1
b. Minor tributaries & immediate drainage (non-point load) -	173	12.5
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	340	24.4
Total	1,395	100.0

2. Outputs -

Lake outlet -	San Angelo water supply	565
	North Concho River	595
	Total	1,160

3. Net annual P accumulation - 235 kg.

* Vosdervize, 1976.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
North Concho River	40,850	58.4
b. Minor tributaries & immediate drainage (non-point load) -	8,050	11.5
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	21,010	30.1
Total	69,910	100.0

2. Outputs -

Lake outlet -	San Angelo water supply	6,375
	North Concho River	6,695
	Total	13,070

3. Net annual N accumulation - 56,840 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
North Concho River	1	13

* Vanderlize, 1976.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.06	0.01	3.2	2.6

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of O. C. Fisher Reservoir at conservation-pool level:

"Dangerous" (eutrophic loading)	0.16
"Permissible" (oligotrophic loading)	0.08

V. LITERATURE REVIEWED

Barrows, David, 1977. Personal communication (reservoir morphometry and hydraulic retention time). Canyon Proj. Off., Fort Worth Distr., Corps of Engrs., New Braunfels, TX.

Koederitze, Thomas (Supt.), 1976. Personal communication (municipal water withdrawal from O. C. Fisher Reservoir and description of lakeshore development). Water Department, San Angelo.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Yost, I. D., 1976. Personal communication (estimate of evaporation from central Texas lakes). U.S. Geol. Surv., Austin.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible] [illegible] [illegible]

Rank	Lake Code	Lake Name	Index No
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NOS.

NUMBER	LAKE CODE	LAKE NAME	INDEX NO.
29	4421	LYNDA & JOHNSON LAKE	239
30	4424	TEXOMA LAKE	217
31	4429	SOMERVILLE LAKE	209
32	4425	SAN ANGELO RESERVOIR	200
33	4433	TEHUACANA LAKE	176
34	4435	GARZA LITTLE ELM RESERVO	173
35	4439	TAYLOR	169
36	4440	GRANGE LAKE	156
37	4441	CORPUS CRISTI LAKE	155
38	4447	HOUSTON LAKE	139
39	4448	LIVINGSTON LAKE	91

[illegible] OF LAKES WITH [illegible] VALUES; NUMBER OF LAKES WITH [illegible] VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] MEAN CHL	[illegible] CHLOPA	[illegible] AQUA ID	[illegible] SECCHI UNITED	[illegible] NO
[illegible]	[illegible] LAKE	29 (11)	55 (21)	24 (9)	3 (1)	67 (25)	30 (11)	264
[illegible]	[illegible] LAKE	19 (7)	47 (17)	5 (2)	19 (7)	82 (31)	36 (14)	259
[illegible]	[illegible] [illegible]	69 (19)	37 (14)	87 (33)	92 (35)	17 (6)	51 (19)	372
[illegible]	[illegible] LAKE	32 (12)	78 (28)	37 (14)	21 (8)	63 (24)	38 (14)	253
[illegible]	[illegible] LAKE	11 (4)	51 (19)	13 (5)	19 (9)	72 (27)	13 (5)	179
[illegible]	[illegible] LAKE	39 (14)	34 (13)	61 (23)	45 (17)	17 (6)	21 (7)	217
[illegible]	[illegible] LAKE	60 (23)	21 (7)	42 (15)	82 (31)	17 (6)	64 (23)	286
[illegible]	[illegible]	0 (0)	61 (22)	11 (4)	5 (2)	42 (15)	0 (0)	109
[illegible]	[illegible] [illegible]	59 (22)	21 (7)	58 (22)	61 (23)	46 (17)	63 (23)	321
[illegible]	[illegible] [illegible]	84 (32)	61 (22)	76 (29)	88 (34)	17 (6)	63 (23)	346
[illegible]	[illegible] LAKE	63 (24)	51 (19)	76 (30)	71 (27)	17 (6)	76 (28)	357

[illegible] DATA TO BE USED IN [illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SUR- [illegible] SEC	[illegible] CHLPA	Z- [illegible]	[illegible] LOSS [illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

[illegible]

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

APPENDIX E

TRIBUTARY DATA

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